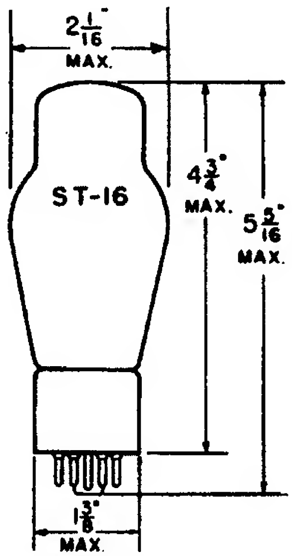
TUNG-SOL

TWIN TRIODE

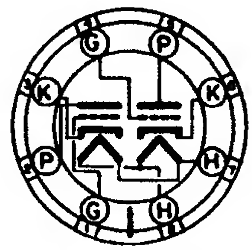


GLASS BULB

HEATER

6.3±10% VOLTS 2.4 AMP.

BASE DOWN MOUNTING POSITION



BOTTOM VIEW
MEDIUM SHELL
8 PIN OCTAL
8BD

THE 5998 IS A MEDIUM MU TWIN POWER TRIODE USED PRIMARILY AS A PASSING TUBE IN SERIES REGULATED POWER SUPPLIES. FOR THIS SERVICE, A TUBE MUST BE ABLE TO PASS LARGE CURRENTS OVER A WIDE VOLTAGE RANGE AND STILL EXHIBIT A LOW INTRINISIC VOLTAGE DROP WHEN OPERATED "WIDE OPEN". THE 5998 NOT ONLY MEETS THESE REQUIREMENTS BUT POSSESSES THE ADDITIONAL ADVANTAGE OF REQUIRING LITTLE GRID VOLTAGE SWING TO CONTROL THESE CURRENTS. THIS PERMITS THE USE OF SIMPLER CONTROL AMPLIFIER CIRCUITS IN THE REGULATED SUPPLY.

ELECTRICAL DATA

HEATER VOLTAGE	6.3±10%	VOLTS
HEATER CURRENT (E_f = 6.3 VOLTS)	2.4	AMP.
MINIMUM CATHODE HEATING TIME	30	SECONDS
TRANSCONDUCTANCE (PER SECTION)	14 000	μMHOS
AMPLIFICATION FACTOR	5.5	
INTER-ELECTRODE CAPACITIES PER TRIODE SECTION:		
GRID TO CATHODE	7.7	μμf
GRID TO PLATE	18.3	μμf
CATHODE TO PLATE	2.5	μμf
HEATER TO CATHODE	10.0	μμf
INTER-ELECTRODE CAPACITIES BETWEEN TRIODE SECTIONS:		
SECTION 1 PLATE TO SECTION 2 PLATE	1.7	μμf

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MECHANICAL DATA

MOUNTING POSITION	BASE DOWN	
BULB	ST-16	
BASE	MEDIUM SHELL-OCTAL-8 PIN JETEC #B8-11	
AVERAGE NET WEIGHT	2.4	OUNCES
MAXIMUM VIBRATION RATING (0 TO 25 CPS)	2.5	G

RATINGS

ABSOLUTE VALUES

	MINIMUM	MAXIMUM	
POWER DISSIPATION PER PLATE	---	15	WATTS
PLATE CURRENT PER PLATE. DC	---	140	MA, DC
IF TUBE VOLTAGE DROP IS TO BE SWUNG MORE THAN 50 VOLTS, THIS CURRENT CANNOT BE REALIZED. SEE PLATE CHARACTERISTICS CURVE.			
PLATE VOLTAGE DC	---	275	VOLTS
HEATER-CATHODE VOLTAGE DC	-100	+100	VOLTS
GRID VOLTAGE	---	0	VOLTS
HEATER VOLTAGE	5.7	6.9	VOLTS
ENVELOPE TEMPERATURE	---	*	°C
ALTITUDE FOR FULL RATINGS	---	10 000	FEET
CIRCUIT VALUES:			
TOTAL GRID CIRCUIT RESISTANCE	500	500 000	OHMS
RESISTANCE PER GRID LEG WHEN TRIODE SECTIONS ARE PARALLELED	500	---	OHMS

CATHODE RESISTANCE:

MINIMUM CATHODE RESISTANCE PER CATHODE LEG SHALL BE 15 OHMS OR THAT RESISTANCE NECESSARY TO PROVIDE 10% OF THE GRID BIAS VOLTAGE, WHICHEVER IS GREATER.

*FOR OPTIMUM TUBE LIFE BULB TEMPERATURE SHOULD NOT EXCEED 150° C. AT FULL DISSIPATION ON BOTH TRIODE SECTIONS IT WILL BE NECESSARY TO PROVIDE FORCED AIR COOLING TO KEEP THE BULB TEMPERATURE WITHIN THIS RATING.

RANGE OF VALUES

	MINIMUM	MAXIMUM	
CONDITIONS: E_f=6.3V, E_b=120V, E_c=-14V.			
PLATE CURRENT PER SECTION DC	50	125	MA.
AMPLIFICATION FACTOR	4.8	6.2	
TRANSCONDUCTANCE	11 000	17 000	µMHOS
HEATER CURRENT PER TUBE	2.20	2.60	AMP.
CONDITIONS: E_f=6.3V, E_b=200V, E_c=-55V, R_k=0			
PLATE CURRENT PER SECTION DC	0	10	MA.
CONDITIONS: E_f=6.3V, E_b=60V, E_c=0V.			
PLATE CURRENT PER SECTION DC	135	---	MA.

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APPLICATION NOTES

THE 5998 IS WIDELY USED AS A "PASSING" TUBE OR SERIES REGULATOR IN CONTROLLED POWER SUPPLIES BECAUSE OF ITS HIGH TRANSCONDUCTANCE AT RELATIVELY LOW PLATE VOLTAGES. TO PROVIDE THE DESIRED OUTPUT CURRENT, MANY TRIODE SECTIONS CAN BE PARALLELED. IF TUBE SECTIONS ARE TO BE PARALLELED, HOWEVER, THE DESIGNER IS STRONGLY URGED TO USE SUFFICIENT RESISTANCE IN EACH CATHODE LEG TO EQUALIZE CURRENT DIVISION AMONG THE TRIODE SECTIONS. RECOMMENDED VALUES FOR VARIOUS OPERATING CURRENTS ARE SHOWN ON THE PLATE CHARACTERISTICS CURVE. IF THE OUTPUT CURRENT OF THE SUPPLY IS NOT FIXED, USE THE RESISTANCE INDICATED FOR THE LOWEST CURRENT THAT APPROACHES THE MAXIMUM PLATE DISSIPATION LINE. CATHODE RESISTANCE IS SUPERIOR TO ANODE RESISTANCE BECAUSE IT PROVIDES MORE BIAS ON THE SECTIONS TAKING GREATER PLATE CURRENT. A CATHODE RESISTOR NEED BE ONLY ONE SIXTH THE VALUE ($\frac{R}{\mu + 1}$) OF A PLATE RESISTOR, AND THEREFORE WILL DISSIPATE ONLY ONE SIXTH THE POWER. IN ANY CASE, THE ONLY LOSSES INCURRED IN USING A RESISTOR IS THE INSERTION LOSS OF THE RESISTOR ITSELF (LESS THAN ONE WATT) AND THE ADDITIONAL VOLTAGE (LESS THAN 10 VOLTS) NECESSARY FROM THE UNREGULATED SUPPLY. A CATHODE RESISTOR ADDS A SMALL ADDITIONAL LOSS BY CAUSING THE PASSING TUBE TO WORK WITH HIGHER BIAS AND HENCE WITH GREATER TUBE DROP.

A THIRTY SECOND CATHODE WARMUP TIME IS RECOMMENDED BEFORE THE PLATE VOLTAGE IS APPLIED. THIS IS ESPECIALLY NECESSARY IN CIRCUITS WHERE THE AMPLIFIER TUBE PLATE RESISTOR IS RETURNED TO THE PLATE SIDE OF THE PASSING TUBE, AS ILLUSTRATED IN THE SIMPLIFIED CIRCUIT IN FIGURE 1. IN THIS CASE DURING WARMUP THE AMPLIFIER TUBE DRAWS LITTLE CURRENT, THERE IS LITTLE IR DROP ACROSS THE RESISTOR, AND THE GRID OF THE PASSING TUBE IS EFFECTIVELY, TIED TO THE PLATE. THE PLATE WILL ATTEMPT TO DRAW EXCESSIVE CURRENT FROM THE PASSING TUBE'S CATHODE AND MAY SERIOUSLY IMPAIR TUBE LIFE. THE CIRCUIT IN FIGURE 2 IS PREFERABLE FROM THE CONSIDERATION OF THE SAFETY OF THE PASSING TUBE BOTH DURING WARMUP AND IN THE EVENT OF TROUBLE IN THE AMPLIFIER CIRCUIT OR IF THE AMPLIFIER TUBE IS REMOVED FROM ITS SOCKET. IT HAS THE ADDITIONAL ADVANTAGE OF PROVIDING A CONSTANT VOLTAGE FOR THE AMPLIFIER CIRCUIT. HOWEVER, IF THE REGULATED OUTPUT IS LOW (BELOW 150 VOLTS) IT WILL BE NECESSARY TO PROVIDE ADDITIONAL NEGATIVE VOLTAGE FOR THE REFERENCE TUBE CIRCUIT. ALSO, IF THE REGULATED OUTPUT VOLTAGE IS TO BE VARIABLE, IT MAY BE NECESSARY TO FOLLOW FIGURE 1.

PASSING TUBE OPERATION CONDITIONS SHOULD BE CHOSEN TO PROVIDE AS LOW A TUBE DROP AS POSSIBLE. A SAFETY MARGIN OF AT LEAST 5 VOLTS FROM THE ZERO BIAS LINE SHOULD BE ALLOWED HOWEVER, FOR VARIATIONS OF INDIVIDUAL TUBES. SUFFICIENT BIAS EXCURSION SHOULD BE ALLOWED FOR OVERCOMING RIPPLE. THE AMPLIFIER CIRCUIT SHOULD BE ABLE TO COUNTERACT THE EFFECT OF UNBALANCE DUE TO TUBE AGING.

A GRID RESISTOR SHOULD BE USED FOR EACH TRIODE SECTION. THIS SHOULD BE ENOUGH TO PREVENT PARASITIC OSCILLATION BUT NOT LARGE ENOUGH TO PREVENT LOSS OF CONTROL DUE TO A SMALL AMOUNT OF "GAS" GRID CURRENT. A VALUE OF GRID RESISTANCE THAT MEETS BOTH THESE CONDITIONS IS 1,000 OHMS. HEATER VOLTAGE SHOULD BE KEPT AS CLOSE AS POSSIBLE TO 6.3 VOLTS AS MEASURED ON THE TUBE PINS. WHEN CONNECTING MANY HIGH DRAIN TUBE HEATERS ACROSS A SINGLE TRANSFORMER, BUS BARS FEEDING FROM "ALTERNATE ENDS" (FIGURE 3) SHOULD BE USED WITH A STRANDED PAIR FEEDING INDIVIDUAL SOCKETS.

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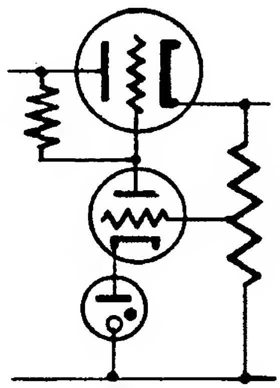


Figure 1

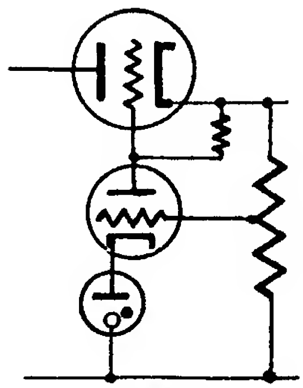


Figure 2

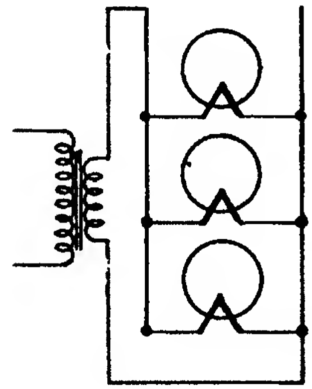
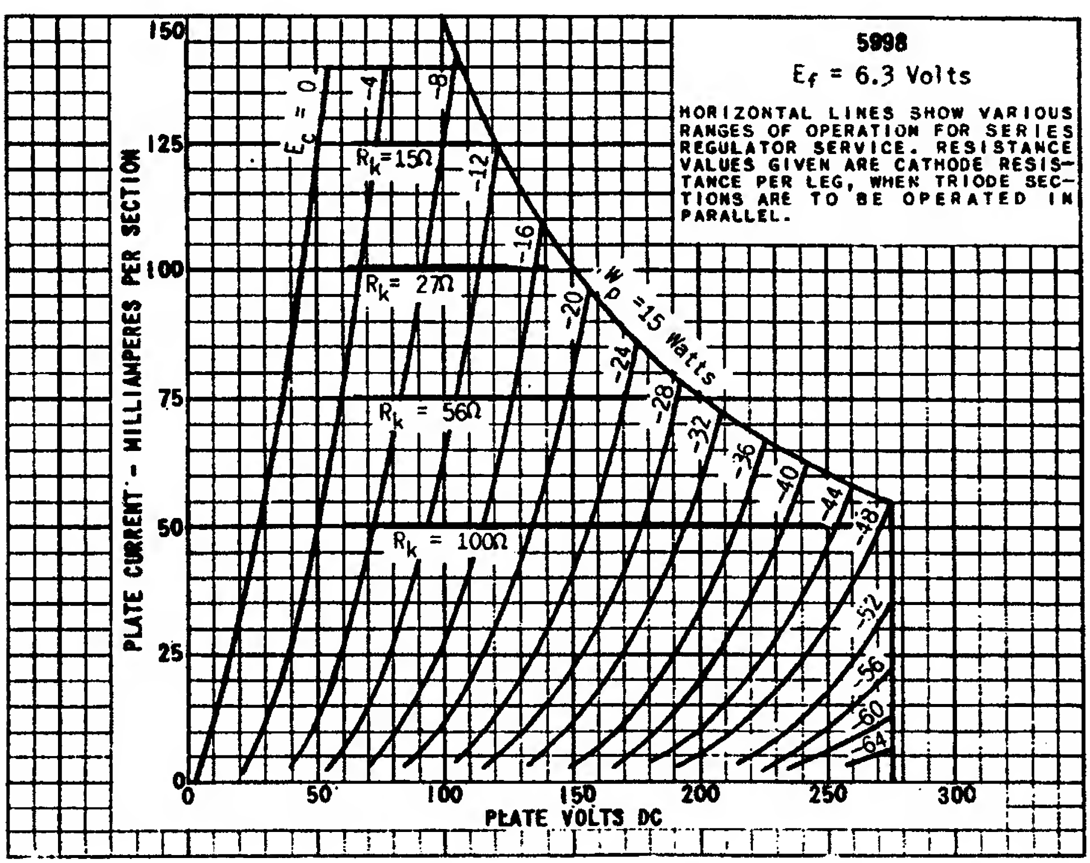
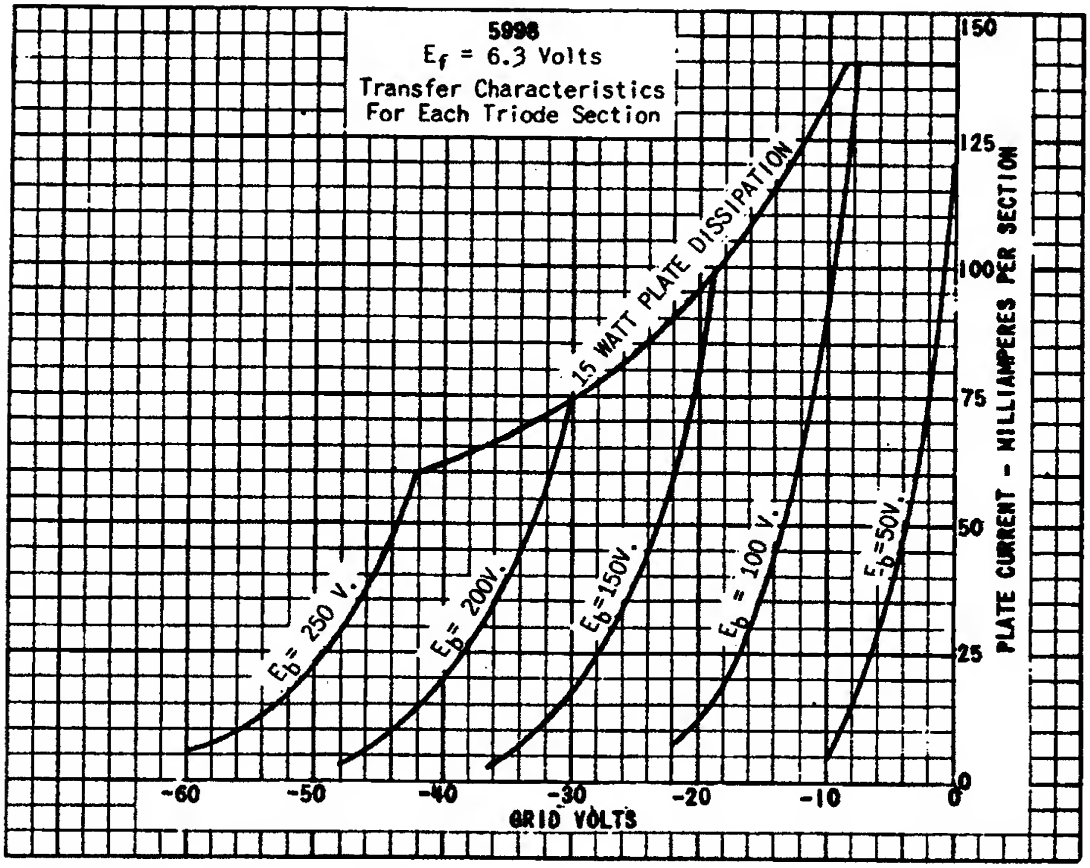
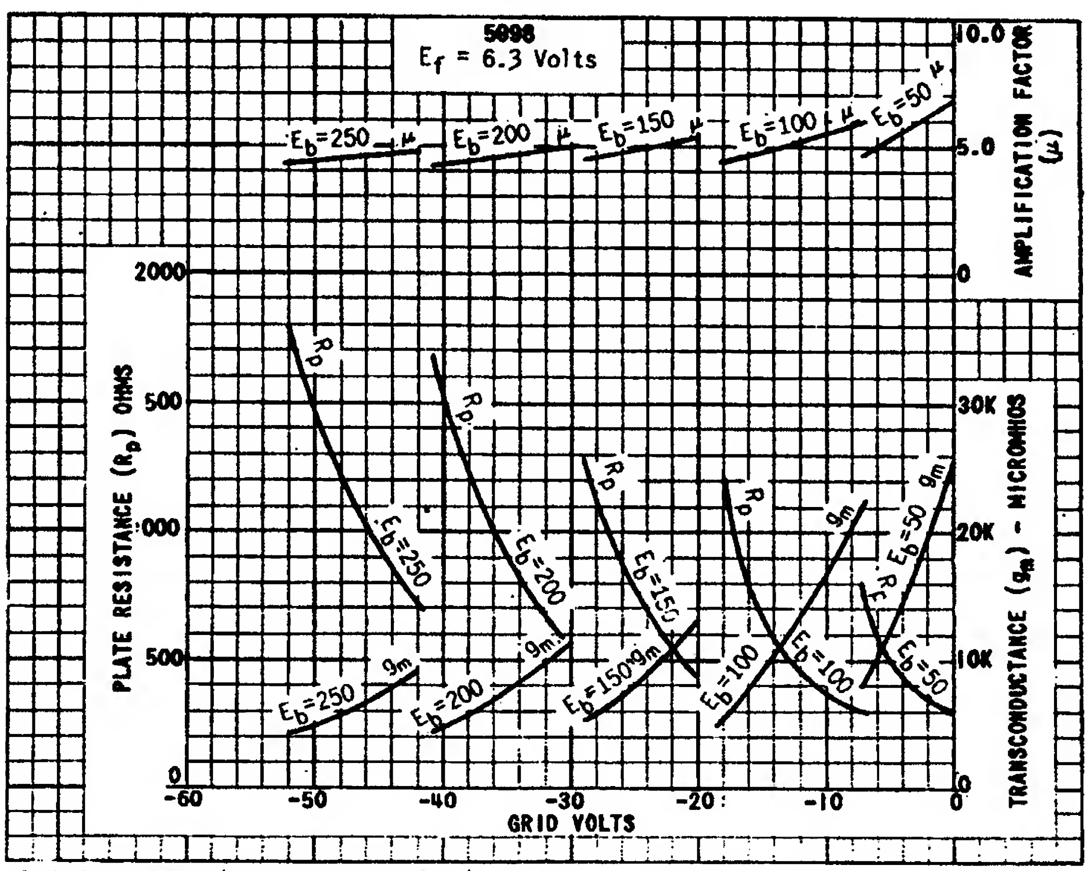


Figure 3




5998
E_f = 6.3 Volts
Transfer Characteristics For Each Triode Section
15 WATT PLATE DISSIPATION
E_b = 250 V.
E_b = 200V.
E_b=150V.
E_b = 100 V.
E_b=50V.
PLATE CURRENT - MILLIAMPERES PER SECTION
150
125
100
75
50
25
0
-60
-50
-40
-30
-20
-10
0
GRID VOLTS


5998
E_f = 6.3 Volts
E_b=250 μ
E_b=200 μ
E_b=150 μ
E_b=100 μ
E_b=50 μ
AMPLIFICATION FACTOR (μ)
10.0
5.0
0
PLATE RESISTANCE (R_p) OHMS
2000
1500
1000
500
0
R_p
E_b=250
E_b=200
E_b=150
E_b=100
E_b=50
g_m
TRANSCONDUCTANCE (g_m) - MICROMHOS
30K
20K
10K
0
-60
-50
-40
-30
-20
-10
0
GRID VOLTS